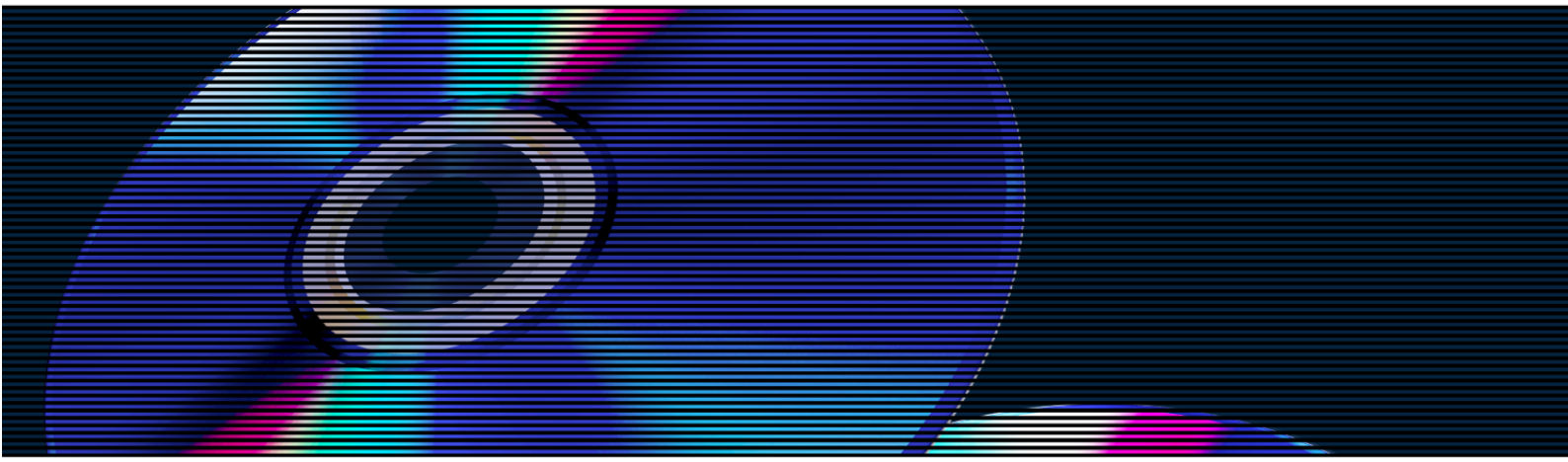
SONY

Optical Disc Archive

Optical Disc Archive Generation 2



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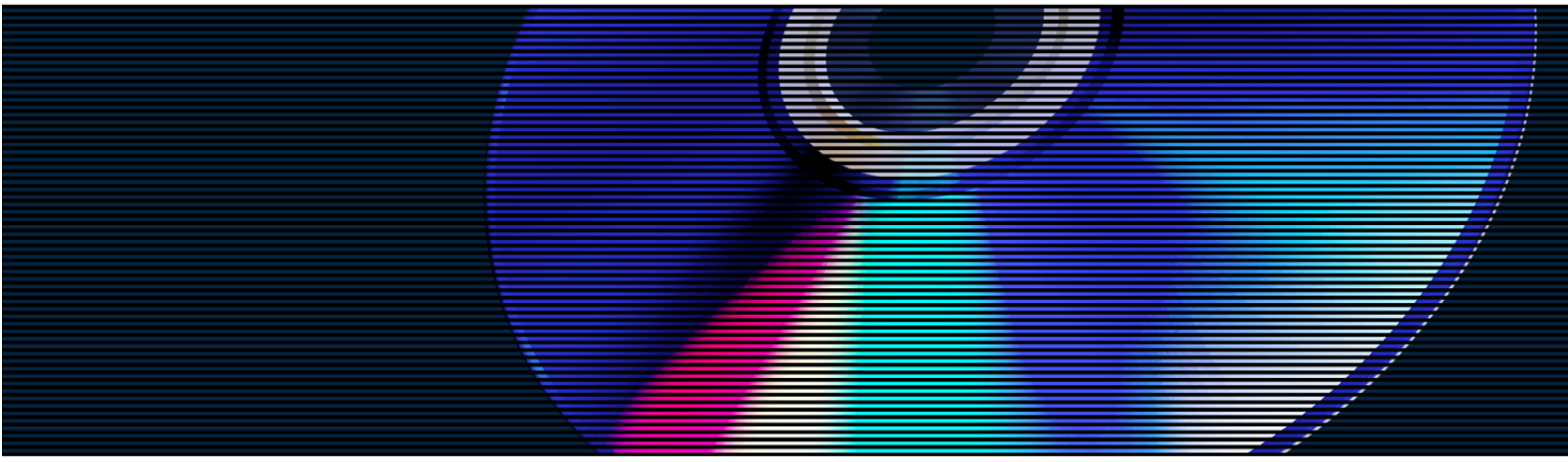

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1 Introduction

1.1 Important Issues Facing the Video Production Industries

Driven by the growing ubiquity of computer networks and the continued rise in processing speeds, businesses everywhere are rapidly embracing IT and moving to digitize their data.

Within the video production industry, progress has been slowed by the difficulty of achieving reliable, stress-free network transmission of the huge quantities of data that constitute video content. Technological advances, however, are gradually removing these obstacles, and infrastructure is now in place to support networked production of data-heavy video content—including 4K, 8K, and high-frame-rate video. The industry is gradually moving into high-value-added production that leverages these new technologies.

Companies are also moving to digitize large quantities of old, long-shelved VTR assets. As it becomes increasingly possible to effectively manage and rapidly search these materials via shared networks, new potential is discovered for the reuse of such assets.

Meanwhile, the industry's business models are also evolving. Changing lifestyles are driving new diversity in content and media. Conventional video broadcasting is now supplemented by cable, satellite, video-on-demand, and more; and opportunities for new content businesses—such as the post-broadcast sales of packaged media—are growing. A major challenge in the video production market is to develop ways to effectively manage, store, and utilize the growing range of video assets—including old video assets, high-value 4K content, and content designed for new modes of distribution.

Sony's Optical Disc Archive system was launched in 2013 for the purpose of meeting these needs. Backed by Sony's extensive experience with optical disc technology, the Optical Disc Archive system delivers extremely reliable long-term storage and broad compatibility, providing stable operation even when running in environments with no air conditioning and where ambient temperature and humidity

levels are uncontrolled. The Optical Disc Archive system is already in wide use in broadcast facilities, businesses, schools and research institutions.

Video content demands have grown rapidly over the past several years. For this reason, Sony is now launching the second generation of the Optical Disc Archive.

This white paper explains how this second-generation system can further benefit video production workflows and presents a new optical disc that constitute the core technology of the new system. Sony hopes to help readers appreciate the technical advances and reliability of the system to encourage them to consider the use of optical disc archiving solutions for their own video production needs.

Optical Disc Archive Generation 2 Products

World's first 8-Channel Optical Drive Unit and Compact Cartridge with 3.3TB capacity

ODS-D280U

Stand-alone USB Drive Unit

ODS-D280F

Fibre-Channel Library Drive Unit

ODC-3300R

Optical Disc Archive Cartridge

2 Development of the New Optical Disc

A new generation of high-capacity optical discs, developed jointly by Sony and Panasonic, serves as the storage media for Generation 2 of the Optical Disc Archive. Sony has also developed the world's first 8-Channel Optical Drive Unit for this system—offering very fast read/write speeds, fully capable of meeting the data needs of 4K video in real time.

In addition to Optical Disc Archive Generation 2 development, Sony is also employing these technologies in new systems designed specifically for data centers called Everspan, where explosive growth is expected in coming years. Sony is working to promote the wide use of optical disc systems at large data centers, such as those used by various industries such as IT, financial and energy (oil and gas). Going forward, Sony will continue incorporating new technical advances into these archive systems, ensuring even higher reliability in the years ahead.

2.1 Ideal media for long-term data storage: Optical Disc

The rapid growth and development of the Internet, as well as growing use of social networks, are central characteristics of today's society. So, too, is the rapid expansion of the Internet of Things (IoT), as security cameras and many other devices and appliances connect to, and communicate over, the Internet. These developments, in turn, are generating enormous quantities of digital data.

Not so long ago, businesses typically ran their own internal servers and managed all their data on-site. But the growth of data volumes and the advent of cloud computing are driving many companies to switch to cloud storage—storing their data offsite at data centers, and accessing it through the Internet.

Large centers, such as those used by global shopping sites and social networks, retain large quantities of data for prolonged periods, with relatively few deletions. The recent development of new parsing technologies will open new possibilities for effectively using and reusing these types of big data.

International Data Corporation (IDC), a US-based research, analysis and advisory firm, projects that worldwide stored data will reach 44 zettabytes (44 x 10^{21} bytes) in 2020—suggesting that demands on data centers are growing very rapidly.

Fig. 1 - 1ZB = 1,099,511,627,776 GB

As data volumes rise, so do storage costs-making it essential to implement storage systems that distinguish between hot (frequently accessed), warm (occasionally accessed), and cold (infrequently accessed) data, and selecting the best storage media for each.

Hot storage demands high performance and is best implemented with high-cost memory—such as flash memory. With warm and cold data, however, performance takes a back seat to requirements of long-term reliability, the ability to maintain large quantities of data at relatively low costs, and the ability to maintain data integrity in "green environments" with limited environmental controls. Sony is convinced that optical disc storage fills all of these requirements, and is therefore ideal for warm and cold storage.

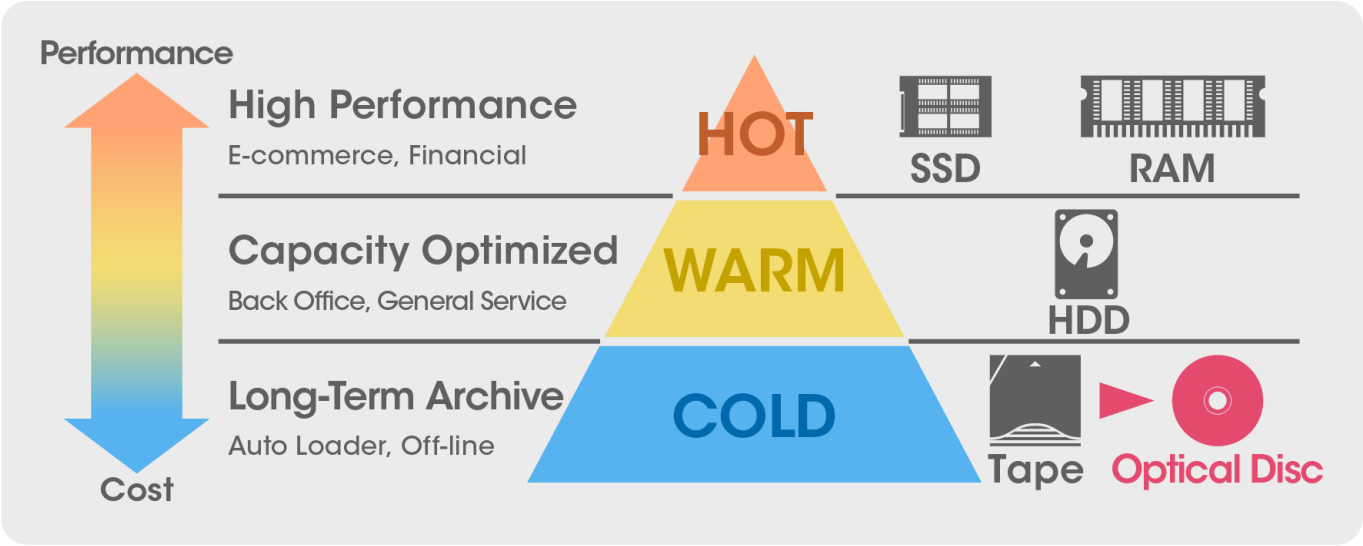


Fig. 2 - Storage System Hierarchy

2.2 Features of Optical Discs

An optical disc loads into an optical drive. This drive uses a semiconductor laser to write data onto the disc and to read data (by reflection) from the disc. Because lasers are used, no contact is made with the disc surface during reading and writing.

These discs also offer excellent tolerance to ambient environment, holding data reliably for over 100 years under any of the temperature and humidity conditions indicated by the blue area in Figure 3. These conditions prevail in most of the world's major cities and enable data storage in "green facilities" lacking air conditioning. This not only achieves —reduced operating costs but facilitates a reduced environmental footprint.

Because new-generation disc system support backward compatible as conventional optical discs, the need for data migration is essentially eliminated. The disc is very durable, water-resistant, allow for random access, as the laser can jump freely to any disc position during reading and writing.

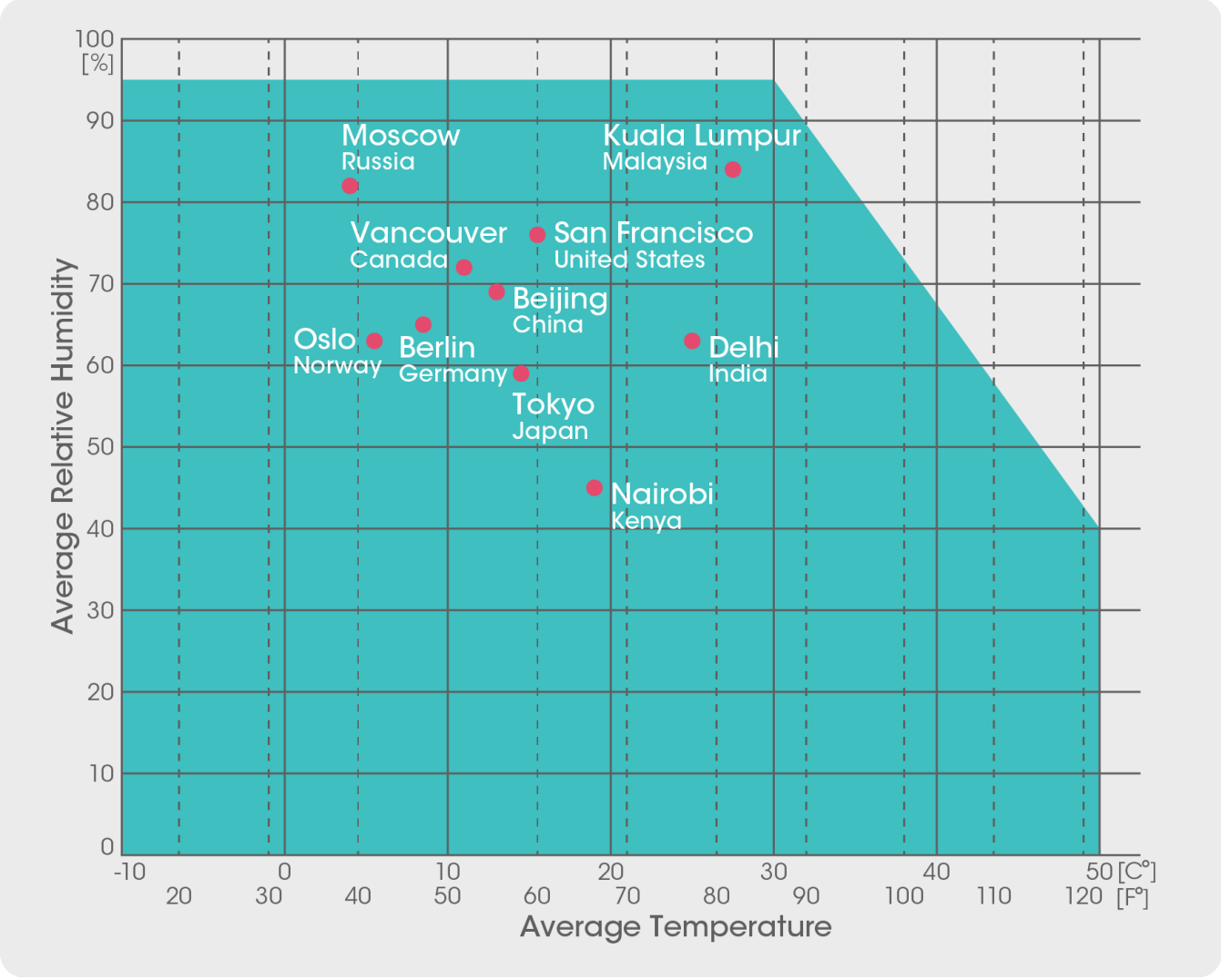


Fig. 3 - Average Temperature and Humidity in Major Cities of the World

2.3 Features of Magnetic Tape

Magnetic tape is another widely used medium for cold storage, consisting of a tape substrate coated with magnetic particles that retain data in the form of magnetic charges. Magnetic heads come into contact with the tape to write (by altering the charges) and read (by detecting the charges). Magnetic tape offers relatively high recording densities, and relatively low cost per unit of capacity.

As improvements in speed and capacity typically lead to a new generation approximately every five years—accompanied by changes in drive systems and software. While writing can go back one generation and reading can go back two, relatively frequent data migrations are required for longer-term storage.

Because heads must wait for the winding mechanism to move tape to the appropriate position, random access is not suitable. Tape is also susceptible to damage from high humidity, water contact, and electromagnetic waves.

As one can see, optical discs and magnetic tape use entirely different technologies. While each has its own benefits and drawbacks for particular applications, optical discs offer a clear advantage when it comes to long-term cold storage.

Optical Disc		Magnetic Tape
Fair	Cost	Good
Good	Generation Compatibility	Fair
Good	Media Storage Environment	Fair
Good	Media Durability	Fair
Good	Random Accessibility	Fair
Long-Term Storage	Primary Use	Backup

Fig. 4 - Requirements Long-Term Storage Medium

2.4 Brief History of the Optical Disc

Jointly developed by Sony and Philips, the world's first 12-cm optical disc—the CD—launched in 1982. Sony continued developing the technology, introducing the first DVD in 1996, and then the first Blu-ray, with five times greater capacity, in 2003. Sony developed the Professional Disc—the first optical disc designed for broadcast and commercial use—in 2003, the same year using it as the recording medium for its XDCAM series. Professional users have rated the professional disc very highly, appreciating its ability to deliver reliable performance even when used in extreme outdoor environments.

Based on these technologies, Sony and Panasonic more recently developed and launched the Archival Disc, a new-generation disc standard delivering even higher capacities at low cost.

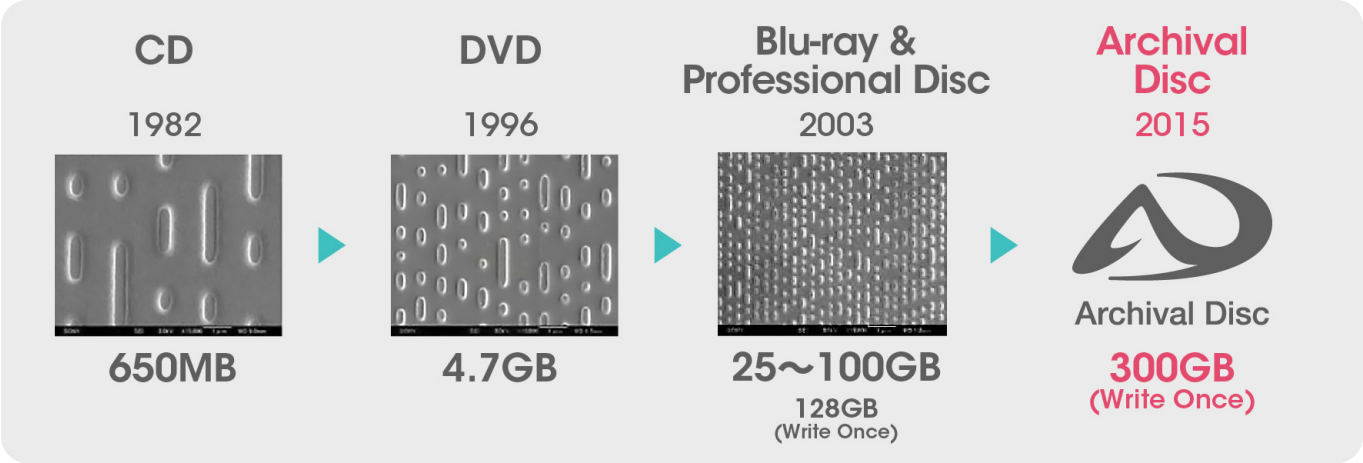


Fig. 5 - Optical Disc Timeline

2.5 Features of the New Optical Disc: Archival Disc

2.5.1 High-Capacity Disc Structure

By implementing six discrete recording layers (three on each side), the new standard achieves a revolutionary jump in storage capacity, to 300 GB per disc.

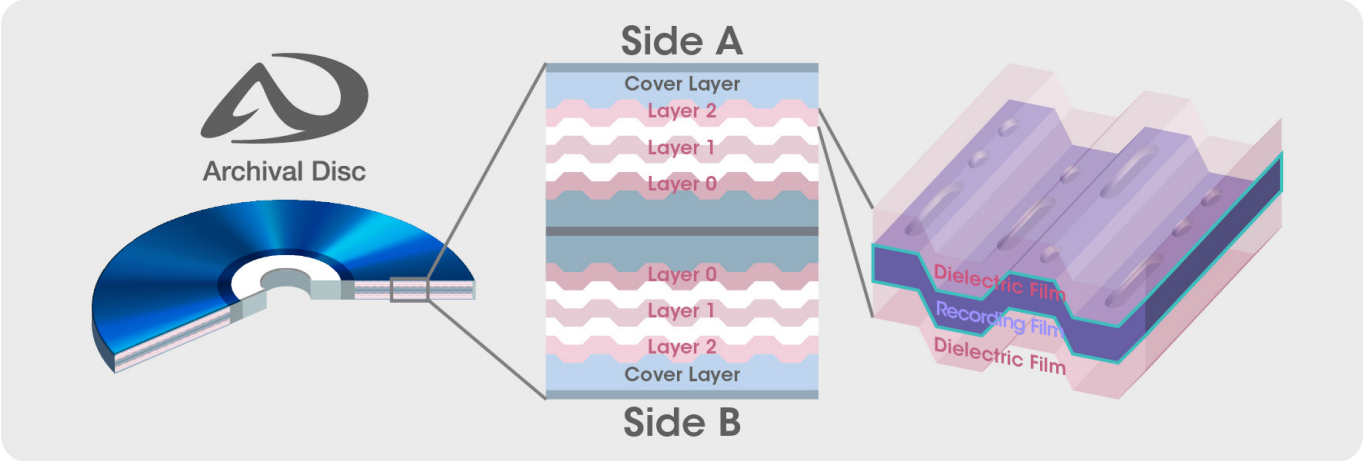


Fig. 6 - Structure of the Archival Disc

2.5.2 Land-and-Groove Recording

To maximize the storage capacity of each layer, the standard uses land/groove recording. each recording layer consists of spiral grooves bordered by concentric lands. Where earlier optical discs recorded only on the grooves, the Archival Disc standard essentially doubles the recording density by recording also on the lands.

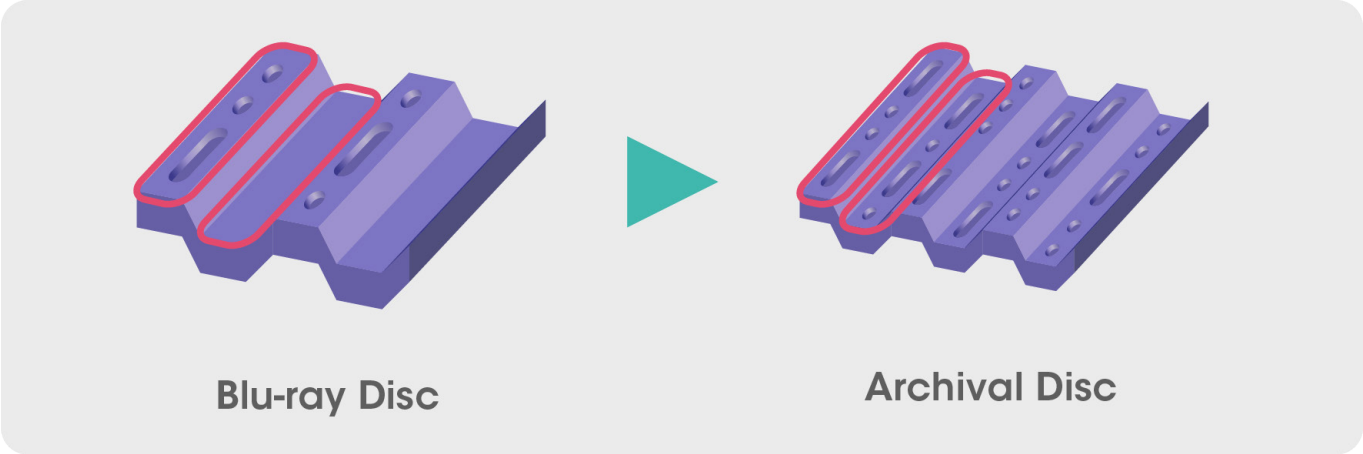


Fig. 7 - High-Capacity Land/Groove Recording

2.5.3 New Oxide-based Recording Materials

Each recording layer is sandwiched between protective layers, in a simple 3-layer design. The use of new oxide-based recording materials realizes improvements in both recording rate, and recording capacity. This use of oxide also boosts the disc's durability. The materials employed can be procured at low cost, and allow for manufacture to be carried out utilizing at existing optical-disc production facilities—enabling efficient mass production while keeping costs down.

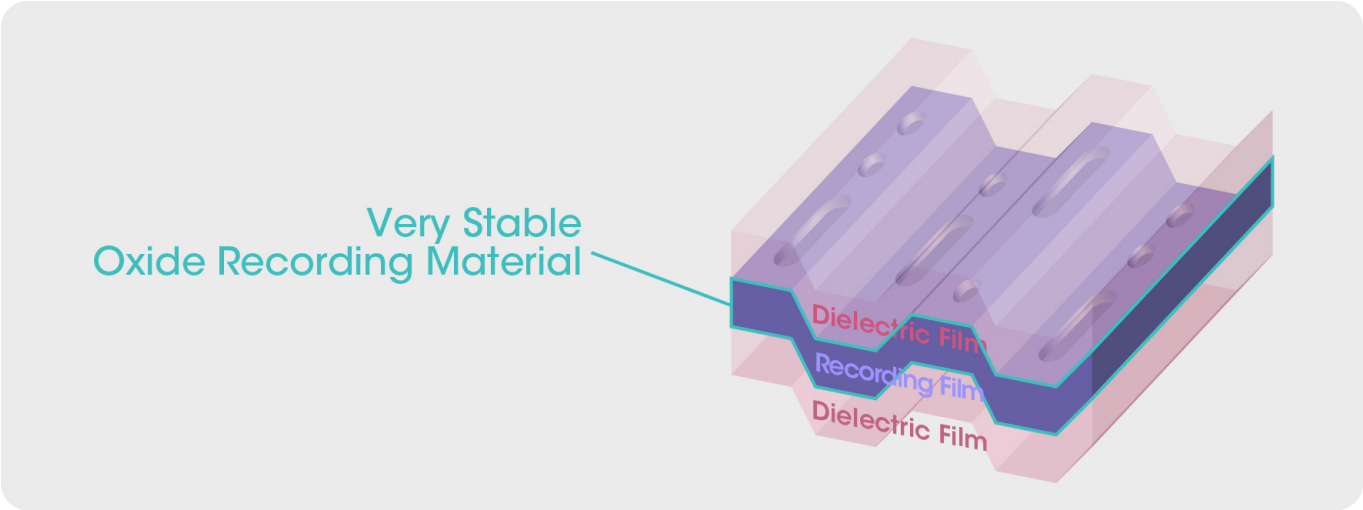


Fig. 8 - Archival Disc's Recording Layer

2.5.4 Archival Disc Specifications

Disc Capacity (Type)	300 GB (Appendable)
Optical Parameters	Wavelength: 405 nm , NA (numerical aperture) =0.85
Disc Structure	Double-sided (3 layers/side), land/groove recording
Track Pitch	0.225 μm
Bit Length	79.5 nm
Error Correction	Reed–Solomon
Recording Mode	Write Once (Appendable)

Fig. 9 - Archival Disc Specifications

Sony Corporation and Panasonic Corporation announced that they had formulated "Archival Disc", a new standard for professional-use, next-generation optical discs. Both companies had started co-development in July 2013 and completed a standard with recording capacity of 300GB per disc by the end of 2015.

Everspan: A Library System that delivers Affordable Optical Disc Archiving to the Data center Storage Market

On March 8, 2016, Sony Optical Archive Inc., a wholly-owned subsidiary of Sony, unveiled the Everspan Library System (Everspan), a scalable optical library system solution that delivers archiving capabilities far exceeding the capacity of what is available in the marketplace today, at a fraction of the cost. Everspan utilizes 300 GB Archival Disc that can support data storage for over 100 years in data center environments.

Everspan is comprised of three units: the Base Unit, the Robotic Unit, and up to 14 Expansion Units. Capacity can be easily increased by adding Expansion Units, which require a nominal increase in power consumption, and cooling requirements. Up to 64 Sony optical array drives can be incorporated into the system, each of which has an average transfer rate of 280 MB/s. Everspan has the ability to store an enormous 181 PB (Petabytes) of archival data. Up to four systems can be connected in a single system, giving access to an astounding 724PB of total addressable storage.

Energy efficiency is an issue facing many enterprises today, and Everspan tackles this with one of the most efficient power/storage ratios in the industry. The Base Unit and the Robotic Unit draw power but all of the additional Expansion Units draw miniscule power to keep the sensors and air filters running. This design allows customers to scale up data storage, only marginally impacting the total system power. In data center environments, at approximately 9kW for a typical 181PB system, (when the system is idle power consumption drops to less than 2kW for a complete 181PB library). The Everspan Library System is currently being evaluated by several companies and institutions.

3 Optical Disc Archive Generation 2

Sony is graduating to the next generation Optical Disc Archive through utilization of Archival disc media and development of the world's first 8-Channel Optical Drive Unit, enabling higher disc capacity and faster transfer rates. Sony has devoted considerable expertise to delivering a system that provides broadcasters and commercial enterprises with robust professional devices, virtually error-free recording, and the many other features required for long-term storage and utilization of valuable video assets.

3.1 Compact Cartridge

The Optical Disc Archive system accepts compact cartridges loaded with 11 Archival Discs, offering a total storage capacity of 3.3 TB. Discs can be easily and safely transported by carrying the entire cartridge, with no need to touch any disc surfaces. Cartridges have passed rigorous quality testing—including dust tests, UV exposure tests, abrasion tests, toxic gas tests, and water resistant tests—to ensure the robustness and reliability required for professional use.

3.2 World's First 8-Channel Optical Drive Unit*

The drive unit holds four laser head assemblies, each containing two heads—for a total of eight laser heads. With two assemblies positioned at the top and two at the bottom, the system can read/write both sides of the disc at the same time. Sony's original high-speed technology provides an average read rate of 2 Gbps (250 MB/s), and an average write rate of 1 Gbps (125 MB/s) with verify—allowing the system to deliver very rapid processing even while serving as a robust, long-term data store.

*As of April 2016, according to Sony investigation

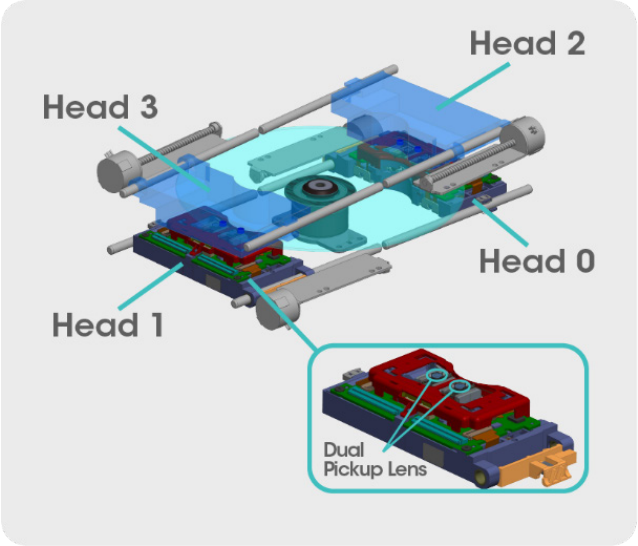


Fig. 10 - Configuration of the 8-Channel Optical Drive Unit

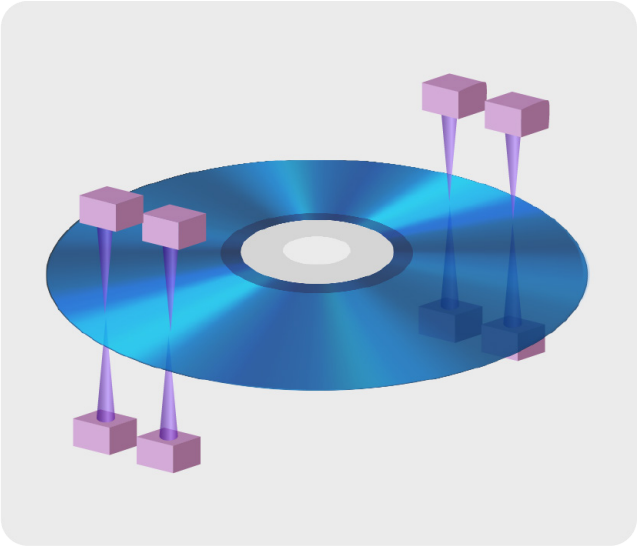


Fig. 11 - Simultaneous Reading/Writing on Both Sides

3.3 Low Error Rate

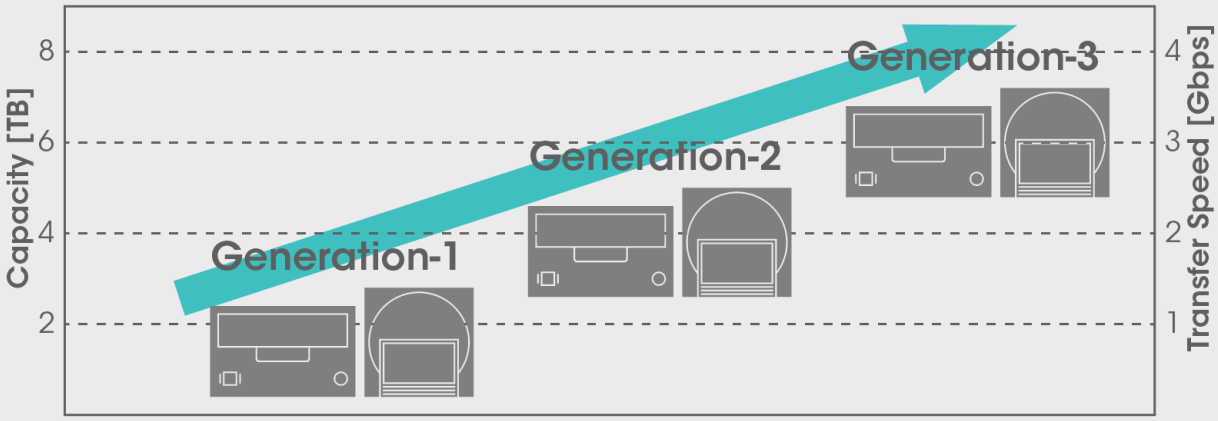
While the Optical Disc Archive uses the same Error Correction Code (ECC) structure as Blu-ray, error rates are significantly reduced. The introduction of a Sony-original parity feature elevates error correction capability, to maintain high reliability for professional use. The system withstands the vibrations of OB vans, is largely unaffected by changes in temperature and humidity during long-term storage, and can be relied on to deliver stable writing performance with very few errors.

3.4 Open File Format

The Optical Disc Archive uses the Universal Disk Format (UDF), an open, vendor-neutral and versatile file system for computer storage media, widely used with optical media. UDF was presented by the Optical Storage Technology Association (OSTA) in 1995, based on standards ISO/IEC 13346 and ECMA-167.

3.5 Future Direction

Going forward, Sony shall continue to develop Optical Disc Archive system, achieving greater capacities and higher speeds.



		Generation-1	Generation-2	Generation-3
Capacity		1.5TB	3.3TB	Up to 5.5TB
Transfer Speed	Read	1.1Gbps	2Gbps	Up to 3Gbps
	Write (w/Verify)	440Mbps	1Gbps	Up to 1.5Gbps

Fig. 12 - Optical Disc Archive: Technology Roadmap

4 Advantages of the Optical Disc Archive

4.1 Reliable Data Storage

Broadcasters are holding increasing quantities of valuable and irreplaceable video—such as historic video and complete-package content—that they cannot afford to lose. But all work environments are at risk of network and server failures, natural disasters, and other unforeseen data-destroying events. The Optical Disc Archive system significantly reduces vulnerability to such events, helping to ensure that valuable data will remain secure for many generations.

Create camera backups immediately after shooting.

To minimize the risk of data loss, make three copies of camera masters: one copy for editing and other uses, a second copy as backup, and a third copy for disaster recovery.

Use multiple media types to build an efficient and reliable archive system.

To achieve reliable storage, operating efficiency, and cost efficiency, the optimal storage system should employ the right medium for each use type.

- Use high-performance HDDs to hold data that will soon be edited or otherwise used.
- For backup, use low-cost-per-unit magnetic tape or optical disc. Use the Optical Disc Archive if efficient random access is required.
- The Optical Disc Archive is ideal for disaster recovery, as it is largely impervious to both water damage and electromagnetic waves.

Store disaster-recovery data in a remote location.

Placing the archive system in a remote location ensures that data will remain safe even if local facilities are wiped out by a hurricane, flood, earthquake, fire, or other catastrophes. The Optical Disc Archive is ideal for this type of remote storage: it is highly resistant to water damage and electromagnetic waves; and it can be housed in a cost-saving green facility with no air conditioning, as it retains its integrity over a wide range of ambient temperatures and humidity.

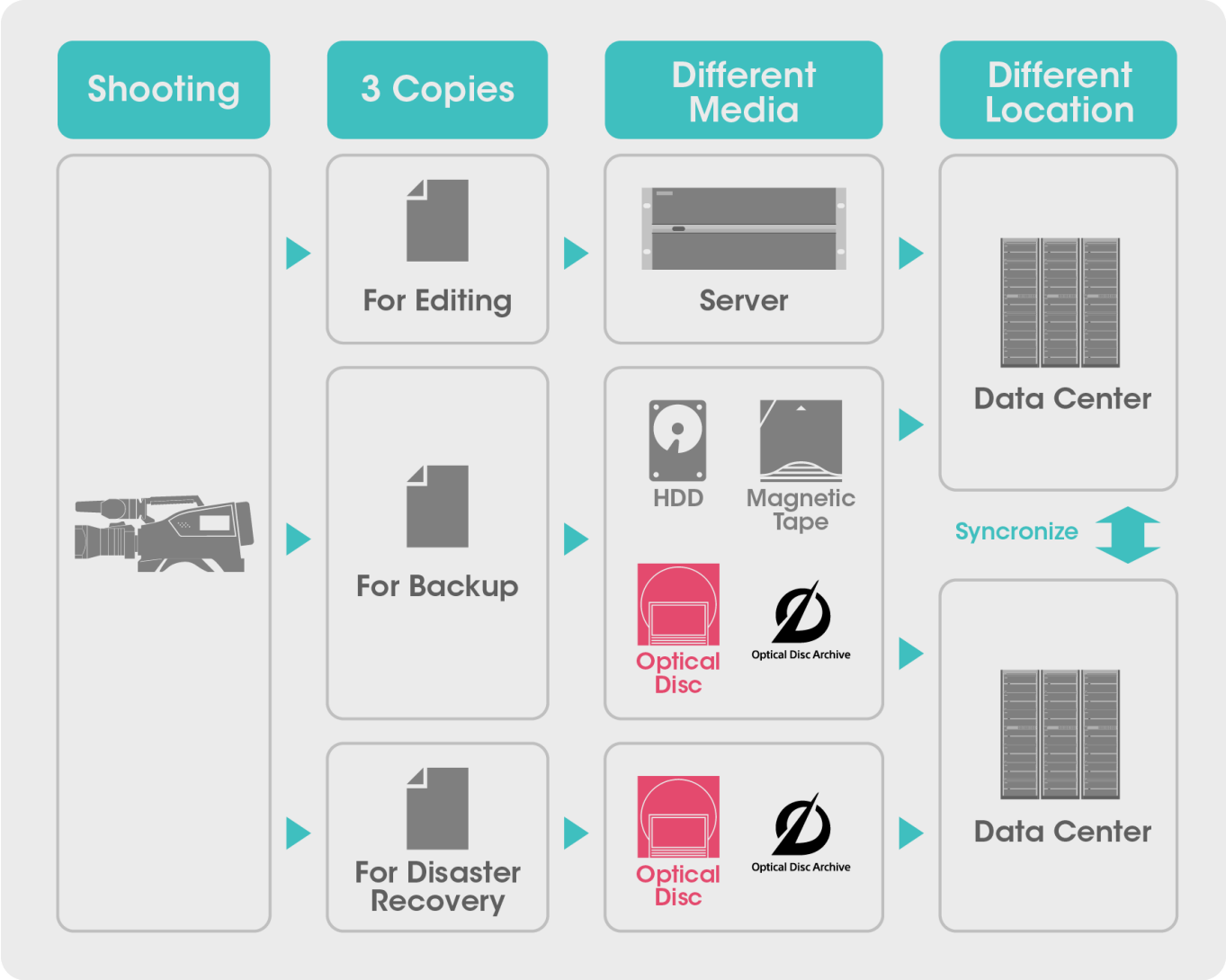


Fig. 13 - Secure Data Archive System

4.2 Advantages for Production Workflows

The recent growth in popularity of high bandwidth video formats such as 1080P, 4K, High Frame Rate and beyond is eliciting broadcasters and video professionals to consider changes to their production workflows and facility infrastructures.

Sony is positioned to ease customer migrations and facilitate workflow improvements in acquisition, infrastructure, post production and archiving.

Let's look at some of the workflow advantages offered by the Optical Disc Archive.

4.2.1 Copy Operation and Nearline Archiving

Many typical post production workflows often repeat copy operations at each stage—at ingest, editing and archiving—a practice that can prove very time consuming when working with large 4K data files. Considerable time can be saved by simultaneously copying new 4K clips to Optical Disc Archive while ingesting to the video server. The system can transfer and save 4K video at speeds surpassing real-time; and once saved, there is no need to copy again to archive.

Optical Disc Archive's random access features enable many middleware tools to access media directly from the cartridge. This means that simple post production tasks such as preview, transcode, trimming etc. can be performed directly from the Optical Disc Archive media without the need for a full restore. This not only saves time but also alleviates pressure on the near-line storage tier resulting in reduced storage costs.

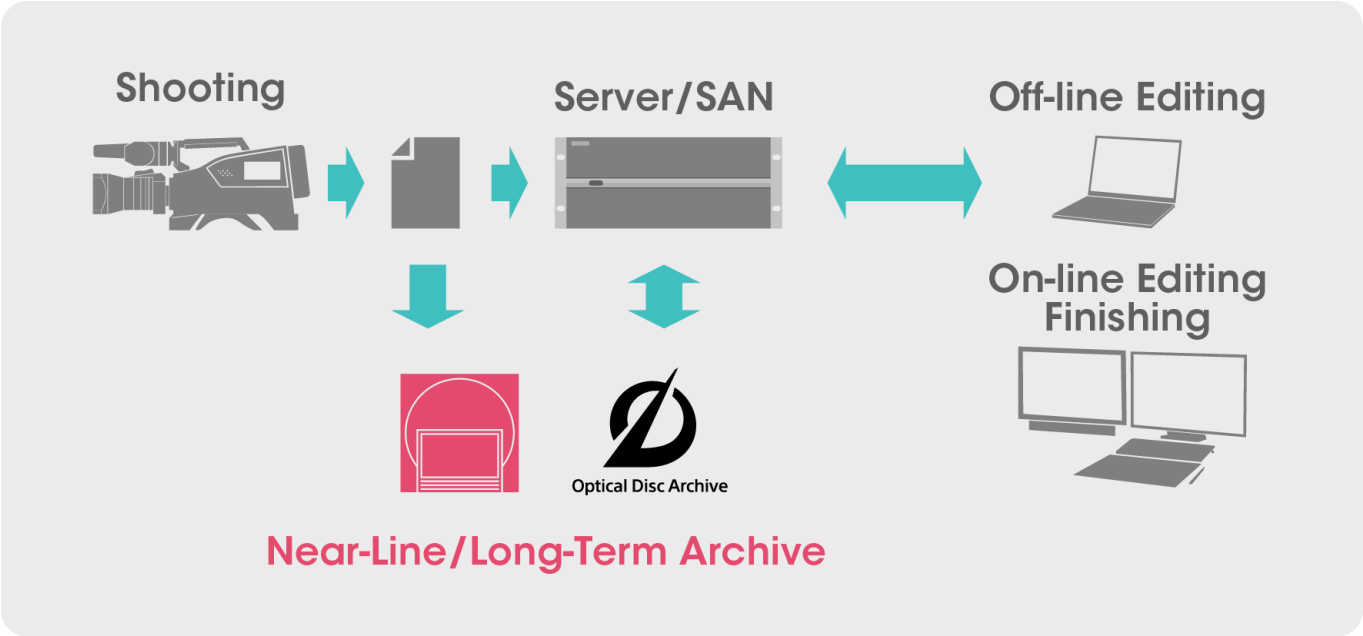


Fig. 14 - 4K Editing Workflow

4.2.2 Live Stream

Coverage of live sports, concerts, and other such events requires prolonged continuous shooting, without retakes. The resulting video must be stored onto two media—one for editing, and one for the backup.

Recording to the backup, however, can place excessive load on infrastructures and interfere with smooth operations. Sony has resolved this problem by developing a transfer-while-streaming feature that simultaneously copies incoming data to both an external HDD (for editing) and the Optical Disc Archive. As was common with VTR recording, as the signal recorded can be instantly archived and also saved to HDD, enabling efficient editing and secure backup.

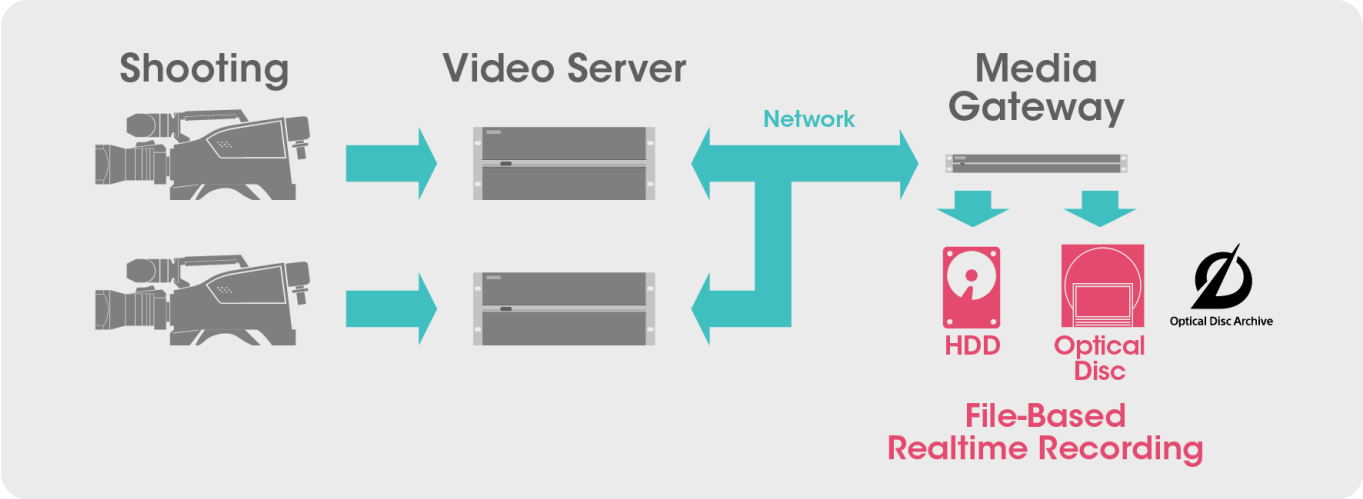


Fig. 15 - Live Streaming Workflow

4.2.3 Archiving Media

When shooting large capacity video such as 4K on location, there is often a worry that the large size of the generated data may exhaust the capacity of the camcorder's onboard flash memory. This problem can be avoided by rapidly copying the data to an Optical Disc Archive, so that valuable flash memory can be freed up as needed. Note also that optical discs offer far more security for long-term storage than flash memory and hard disks—as hard disks in commercial use have an estimated lifetime of only three to five years; while flash memory, because it could be deteriorated by internally generated electronic signal, remains reliable for only a limited number of erase/write cycles. Immediate copy to Optical Disc Archive ensures that valuable video will remain secure for many years to come.

4.2.4 Delivery Media

The Optical Disc Archive's large capacity, high speed, and cartridge-protected solidity make it an excellent medium for delivery of video. A production company that delivers data in this form to the broadcaster is providing not only the content but also an archive; and the broadcaster can then easily perform further processing, if required, by rapidly locating desired clips and transferring them into their video server. Sony is actively working to encourage the broadcast industry to adopt Optical Disc Archive cartridges as a delivery medium.

Digitization Solutions

Memnon: Offering Digitization Solutions starting in the European, American and Middle East Markets

Broadcasters, production companies, and other content holders are not only handling large and growing quantities of daily content, but are also much concerned with digitizing the massive VTR assets currently sitting on shelves.

In July 2015, Sony purchased Belgium-based Memnon Archiving Services S.A., an industry leader in digitization services and digital archiving.The company has broad experience in creating digital archives for national libraries, museums, broadcasters, and movie libraries. Sony and Memnon are working together to provide effective solutions for digitizing video assets and carrying them safely into future generations.

5 Towards Wider Use of the Optical Disc Archive

Sony is promoting an open platform approach and providing technologies and support to encourage other manufacturers to develop supporting products for Optical Disc Archive. This cooperation is opening up a wide range of total archiving solutions for large and small enterprises alike. Middleware, media-asset management systems, and similar products are already being released by cooperating manufacturers. As of April 2016, 42 companies have announced their support for the Optical Disc Archive.

Fig. 16 - Optical Disc Archive Supporting Manufacturers

6 Conclusion

In 1978 Sony teamed with Philips to develop the CD. However several years earlier, Sony had already demonstrated what was probably the world's first digital audio disc. At that time, Sony made the decision not to use the existing video-signal model in favor of developing original technology to directly record digital audio on optical disc. In 1977 the company exhibited a prototype that played twice as long as a video-signal-based recording, that became one of the first designs to use error-correction code to reduce the error rate. Sony has continued developing optical disc technology through the years since, achieving many important advances along the way.

Sony's Archival Discs are the newest implementation of optical disc technology and reliability, leading the way to the second generation of Optical Disc Archive products and creating data center systems Everspan, that can effectively manage huge quantities of data. Going forward, Sony will develop optical disc technology and promoting optical discs as the best medium for protecting valuable data into the future.

Sony believes that the Optical Disc Archive can serve as the core of highly productive archive systems capable of managing and storing valuable, high-volume data—including 4K video, future-generation video, older video assets, and multimedia video content. Sony will continue developing this technology to meet and anticipate emerging needs.

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